Space-Charge Driven Emittance Growth in a 3D Mismatched Anisotropic Beam

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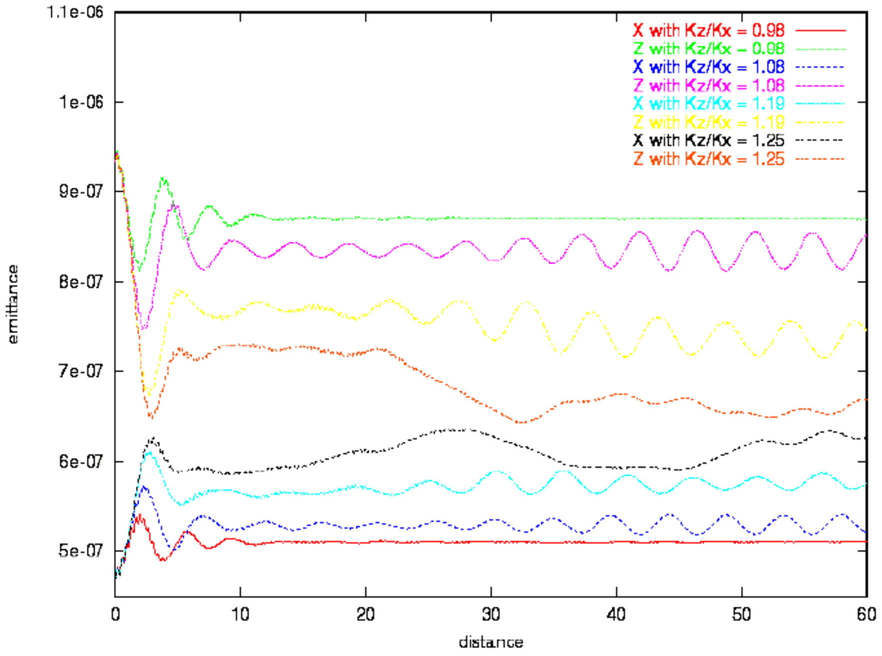
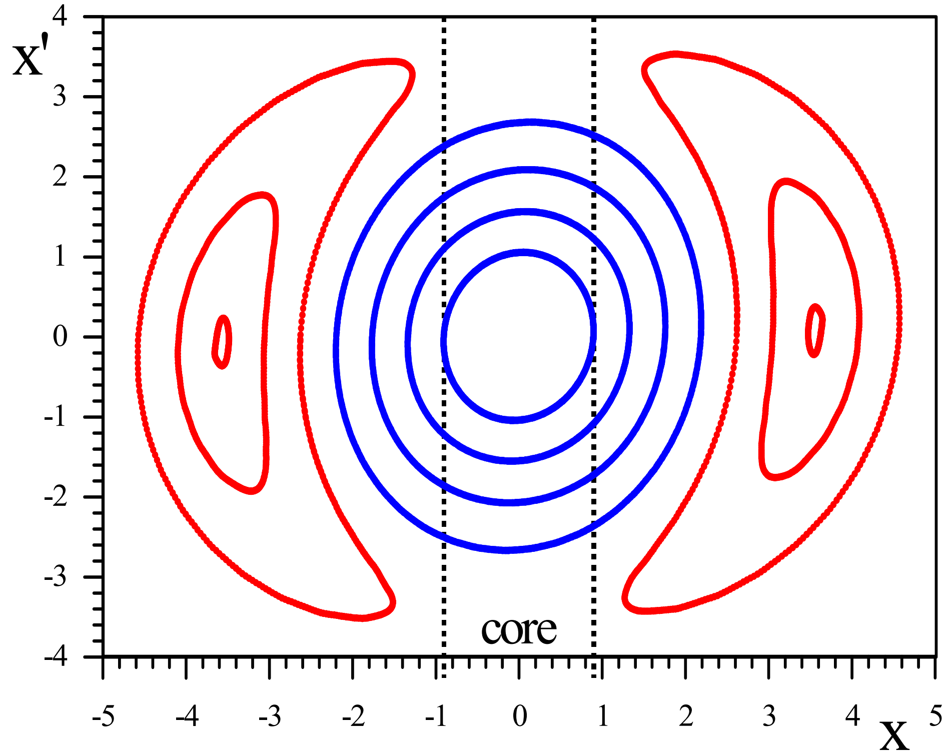
Emittance Growth from Equipartitioning

- Equipartitioning: longitudinal and transverse emittance exchange
- Difference resonances driven by space charge, not subject to thermodynamics
- The rate of equipartitioning: nonoscillatory eigenmode
- Major 4th order resonance
- Core interactions



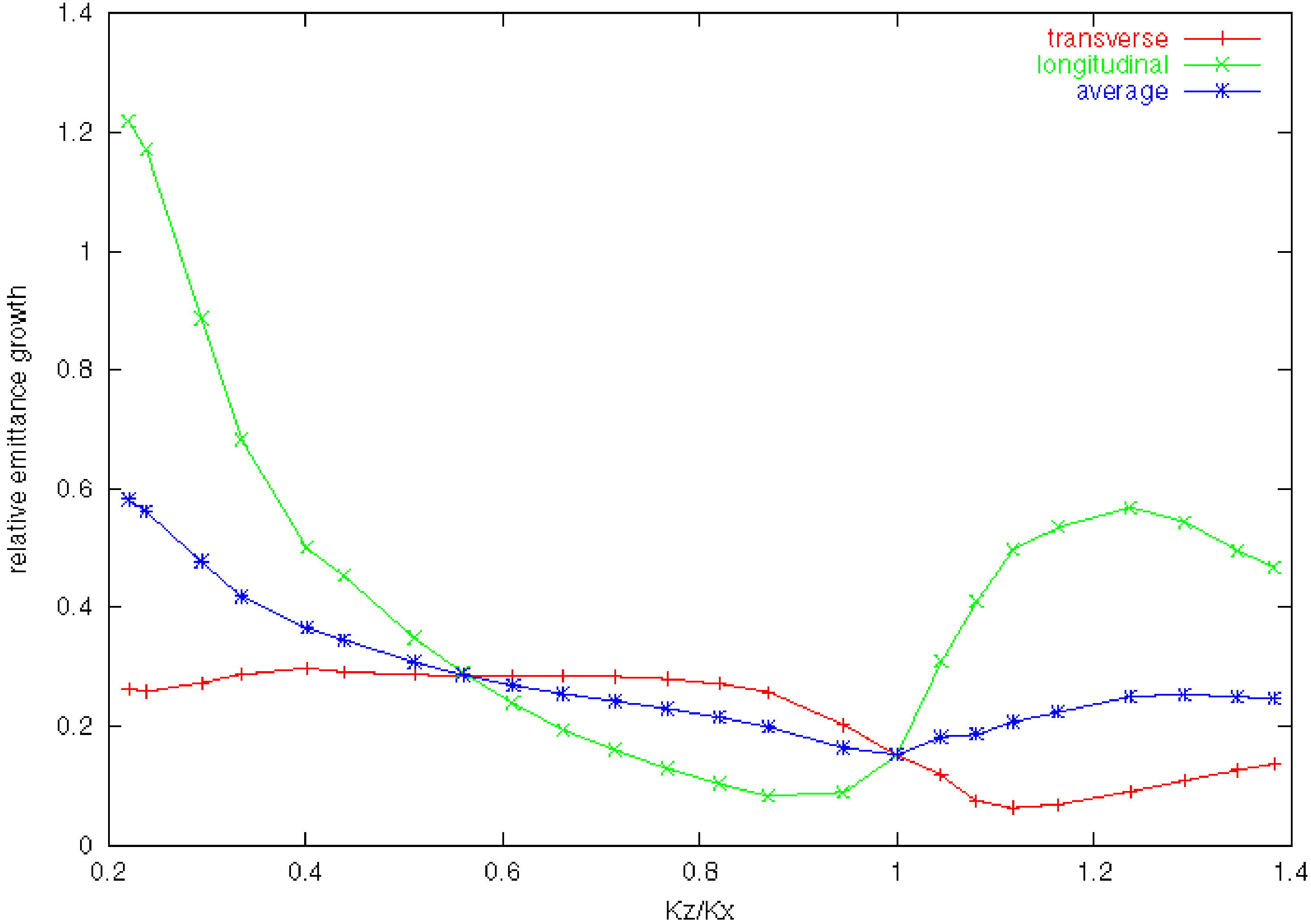
Emittance Growth from Mismatch Induced Halo

- Envelope oscillation from mismatch
- Particle – envelope resonance
- Most dangerous resonance: 2:1 → large amplitude halo
- Multi-dimensional parameter space
- Emittance growth through Landau damping.
- Free energy equivalence of emittance growth



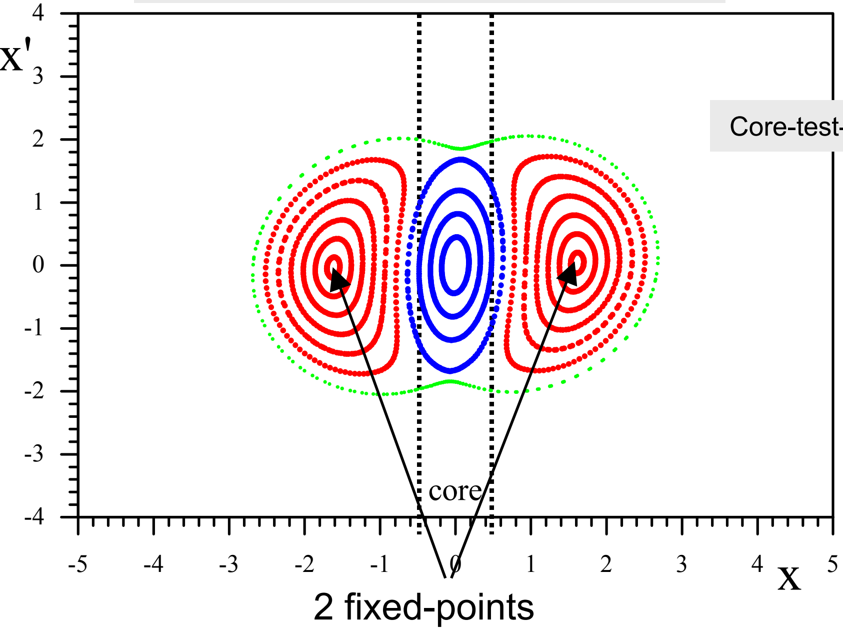
Final RMS Emittance Growth vs. Tune Ratio in a Mismatched Anisotropic Beam

(Kx/Kx0 = 0.6, Ez/Ex = 1, Gaussian Distribution.)

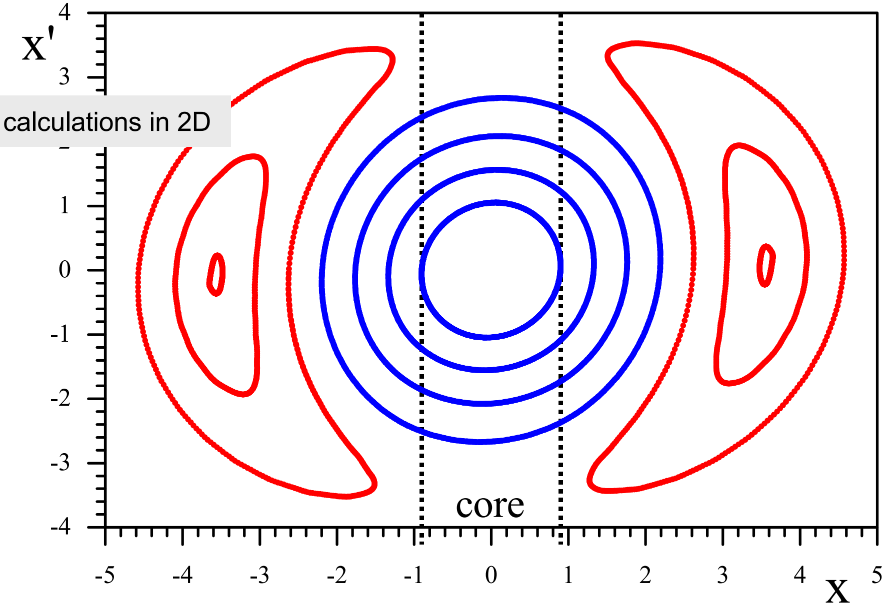


Attraction of Fixed-Points by Stronger Focusing

Round beam breathing mode



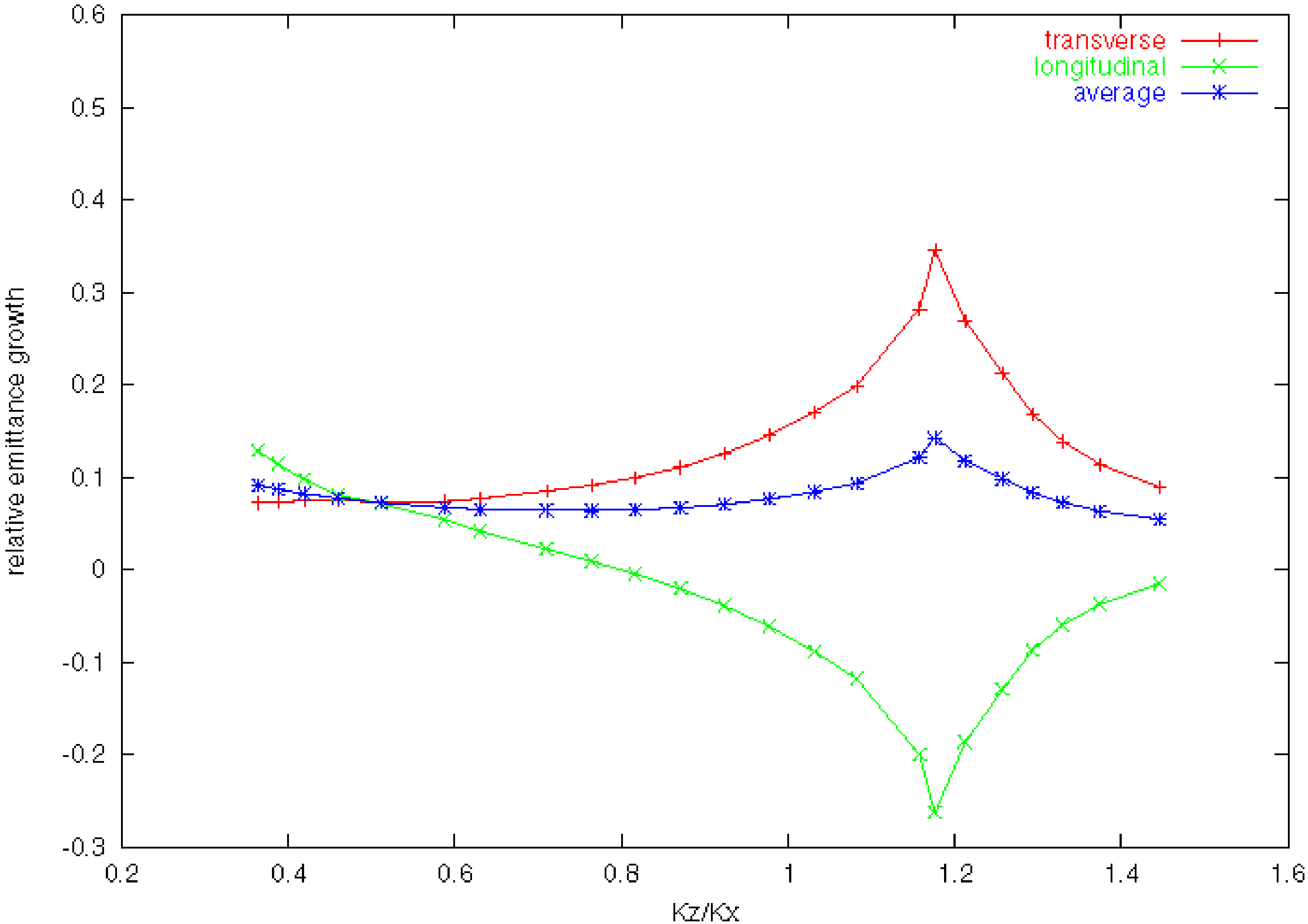
Core-test-particle calculations in 2D



Weaker focusing in x ($k_x<k_z$):
halo amplitude in principle
arbitrarily large,
but won‘t be populated!
fixed points + halo attracted for $k_z>k_x$
results in stronger rms emittance growth

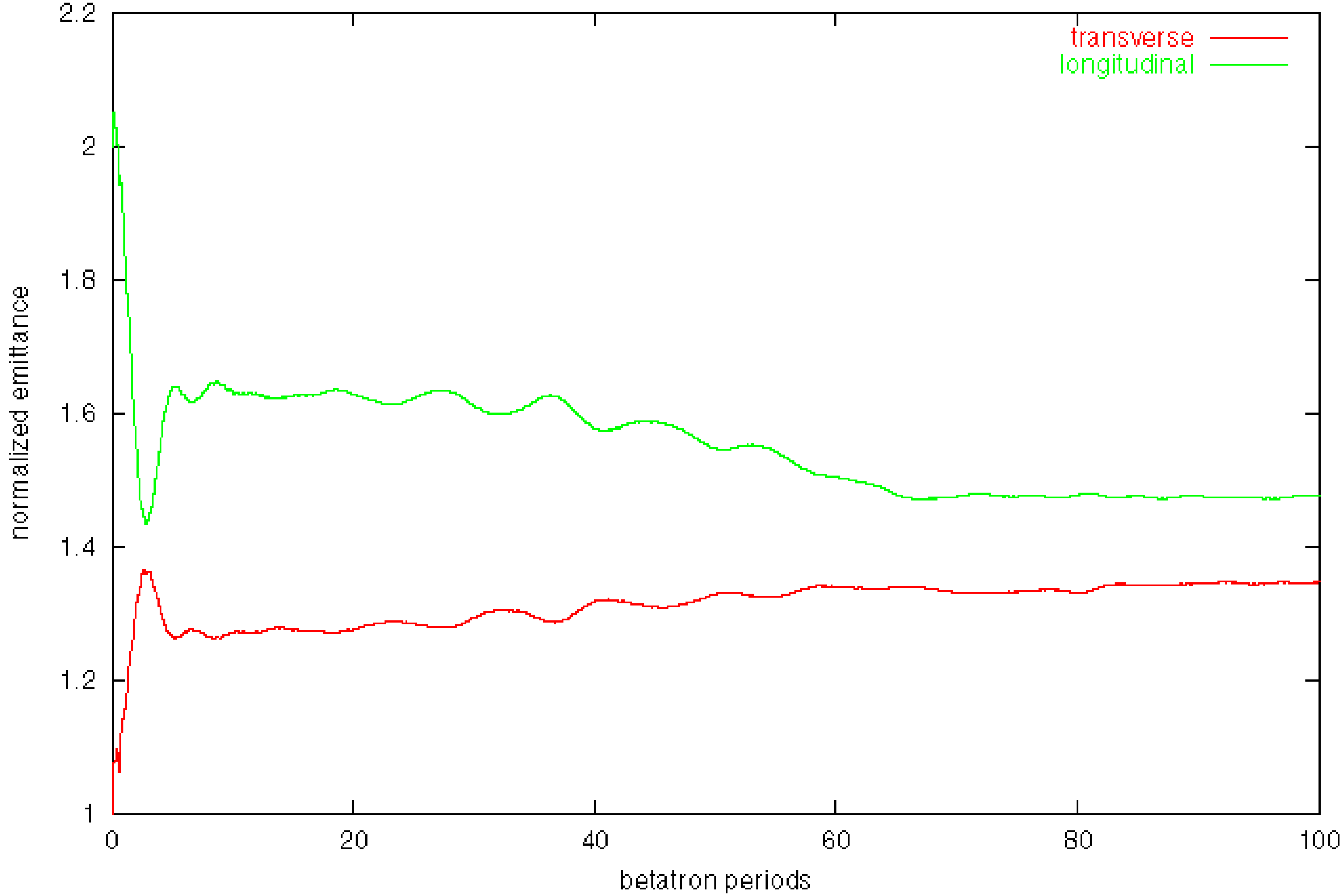
Final RMS Emittance Growth vs. Tune Ratio in a Matched Anisotropic Beam

(Kx/Kx0 = 0.6, Ez/Ex = 2, Gaussian Distribution.)



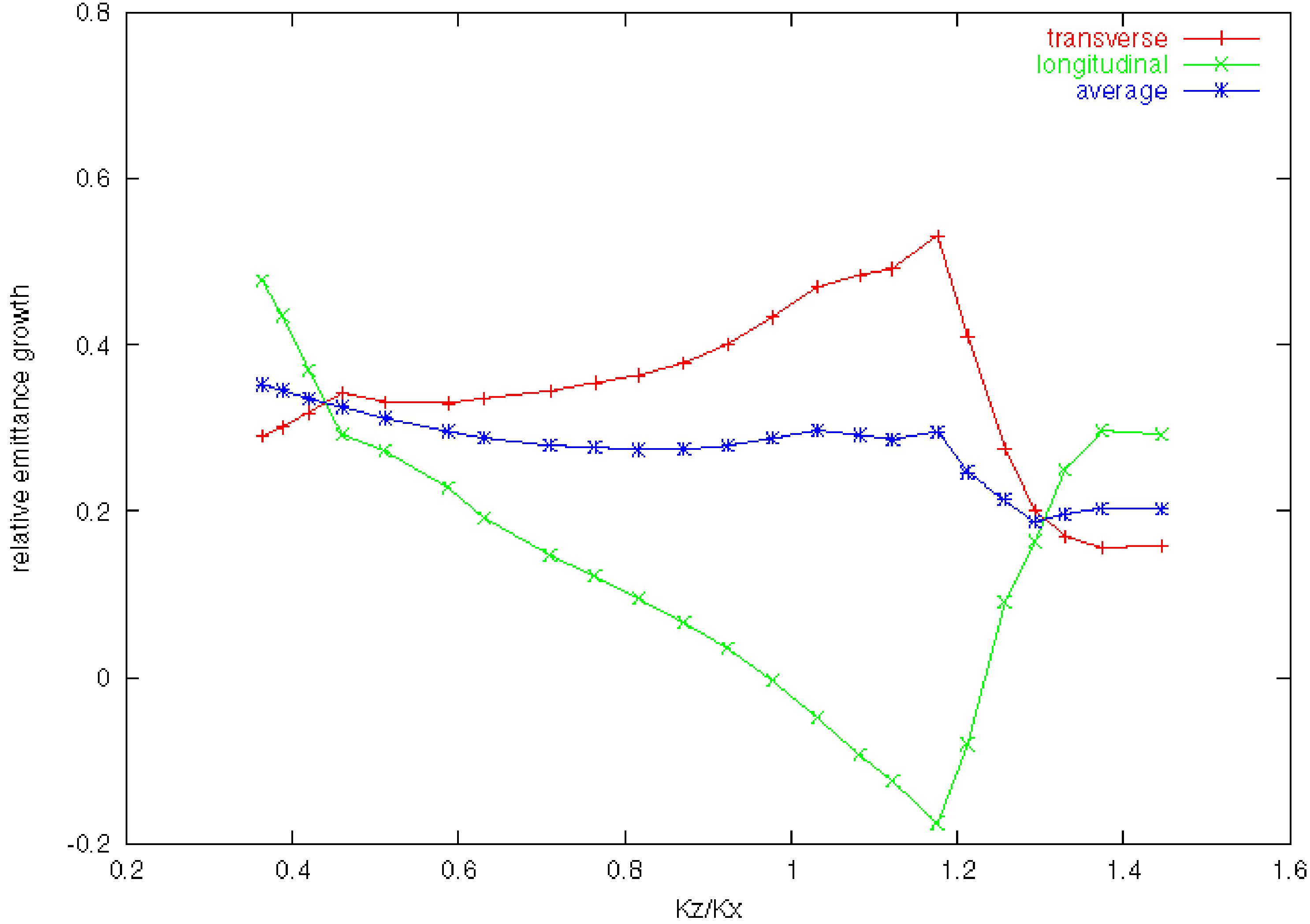
RMS Emittance Evolution in a Matched Anisotropic Beam

(Kz0/Kx0 = 0.98, Kx/Kx0=0.6, Kz/Kx = 1.18, Ez/Ex = 2, Gaussian Distribution)



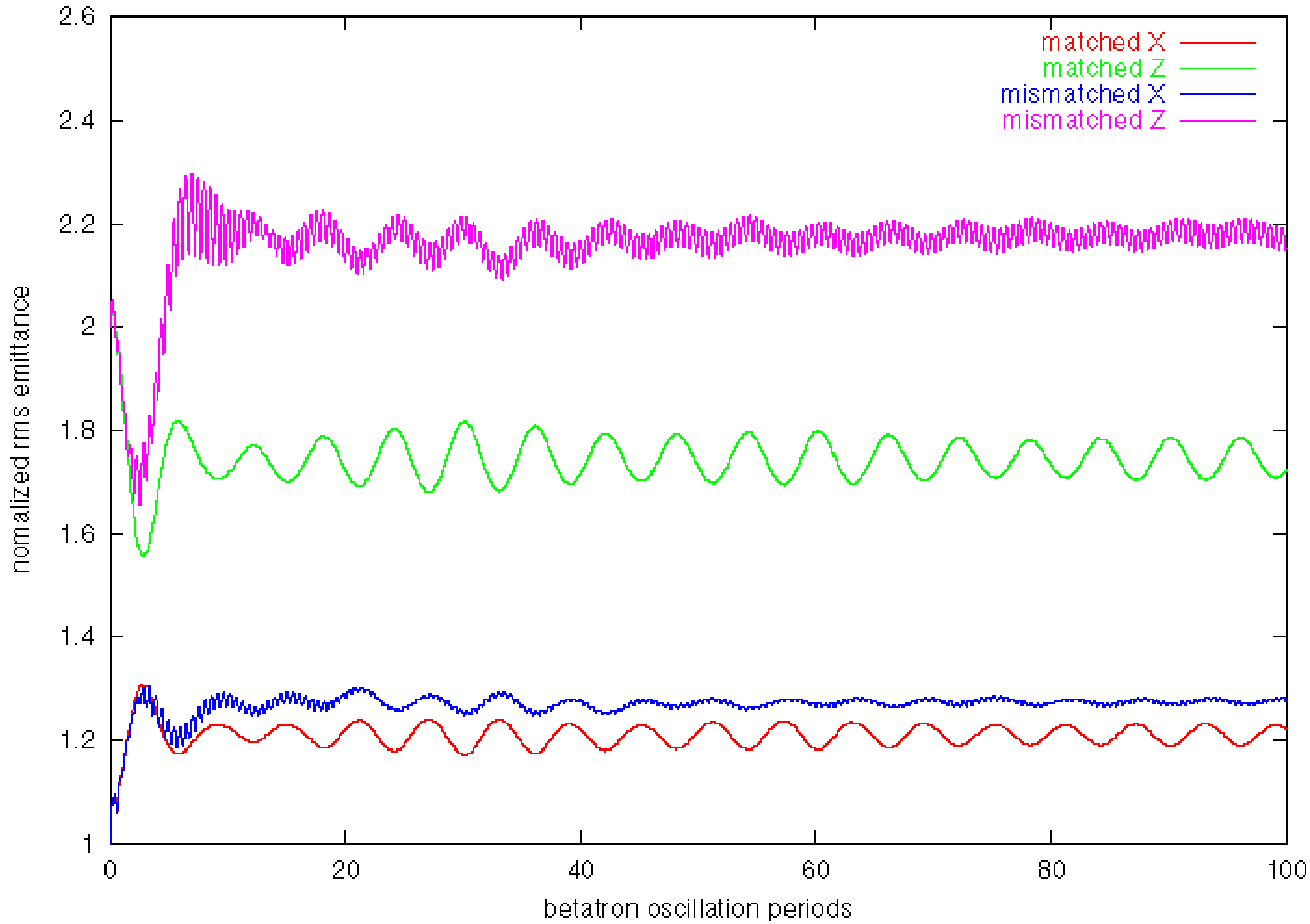
Final RMS Emittance Growth vs. Tune Ratio in a Mismatched Anisotropic Beam

(Kx/Kx0 = 0.6, Ez/Ex = 2, Gaussian Distribution.)



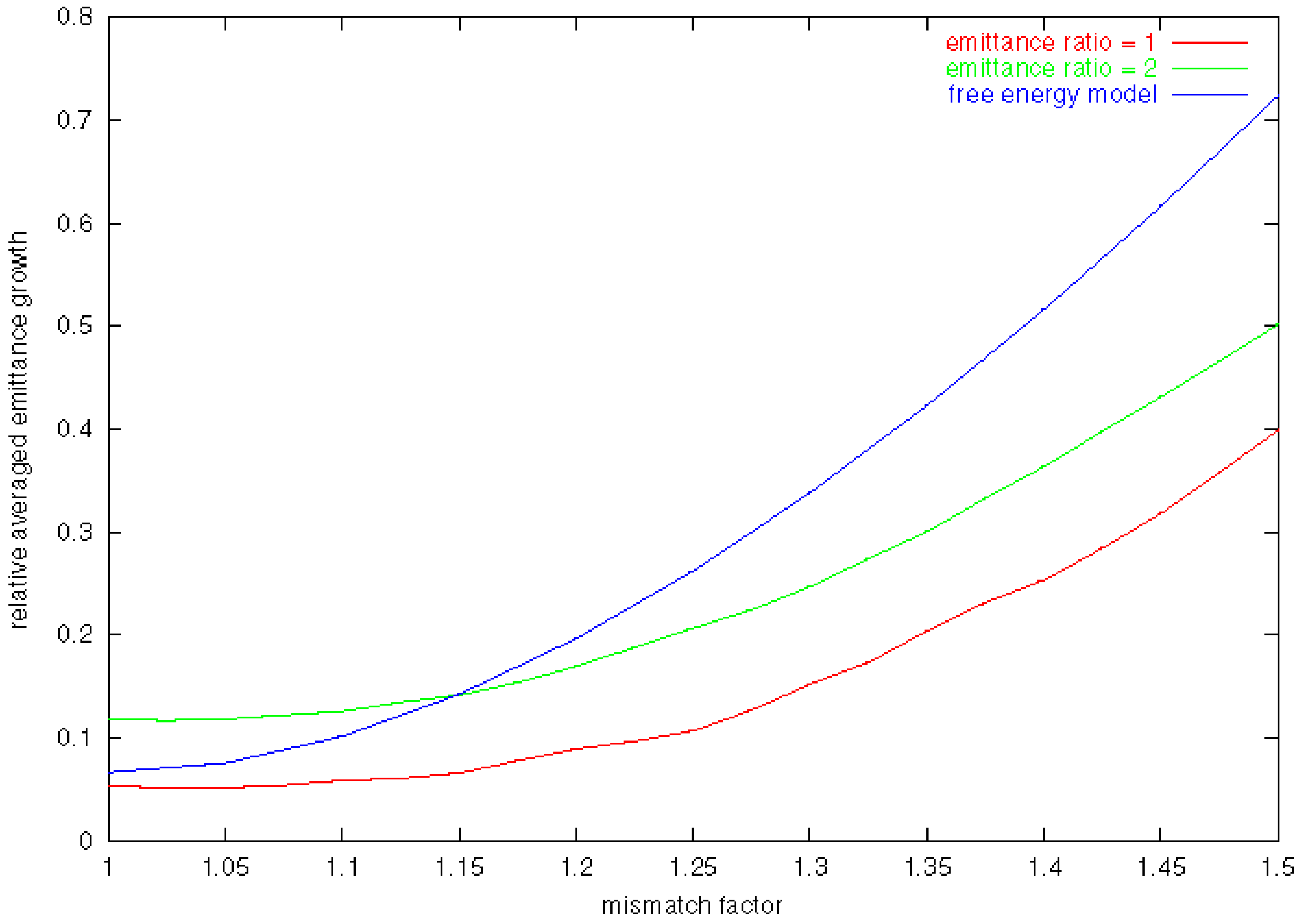
RMS Emittance Evolution in a Matched and Mismatched Anisotropic Beam

(Kz0/Kx0 = 1.025, Kx/Kx0=0.6, Kz/Kx = 1.26, Ez/Ex = 2, Gaussian Distribution)



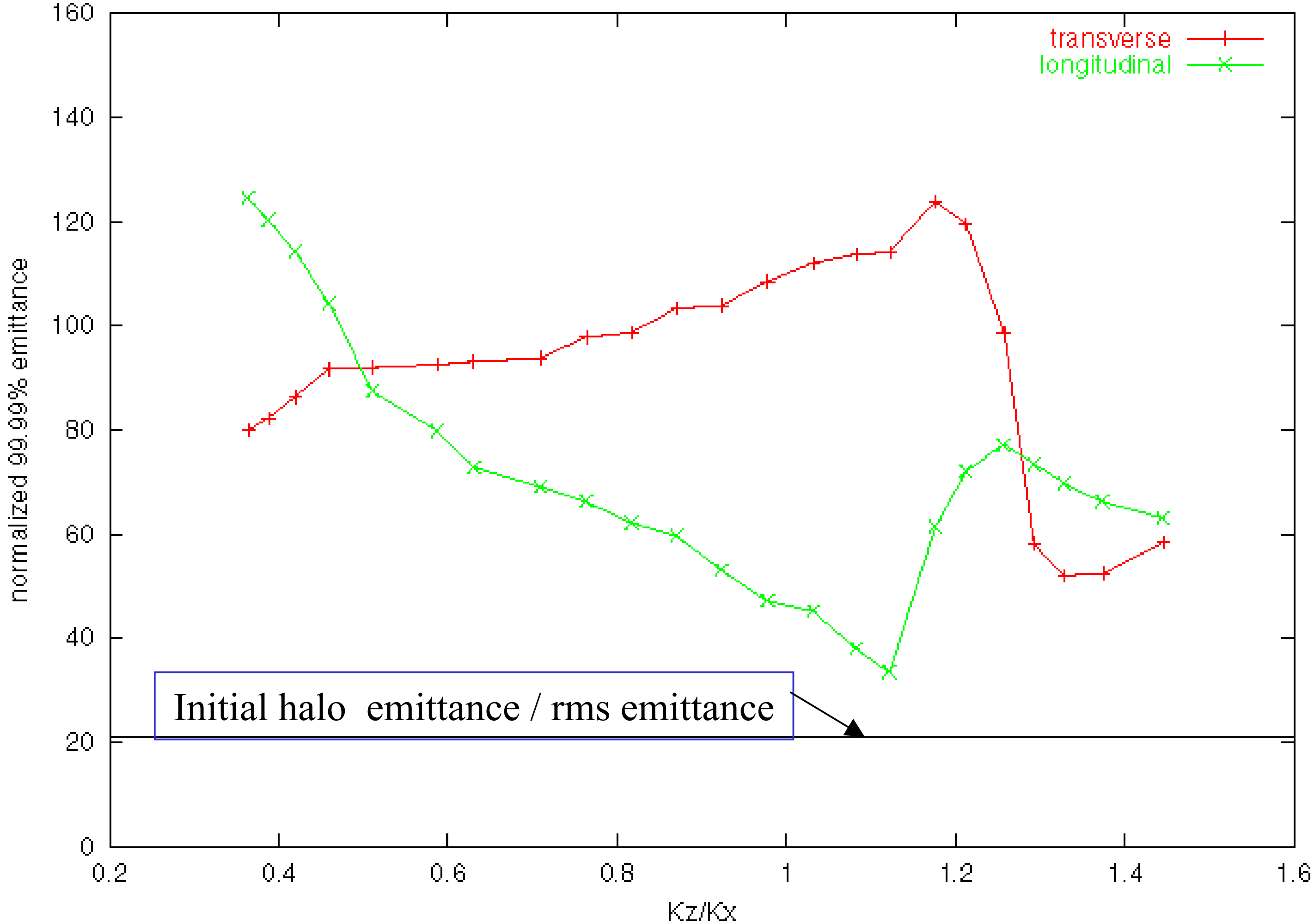
Final Averaged RMS Emittance Growth vs. Mismatch Factor

(Kz0/Kx0 = 1.0, Kx/Kx0 = 0.6, Gaussian Distribution.)



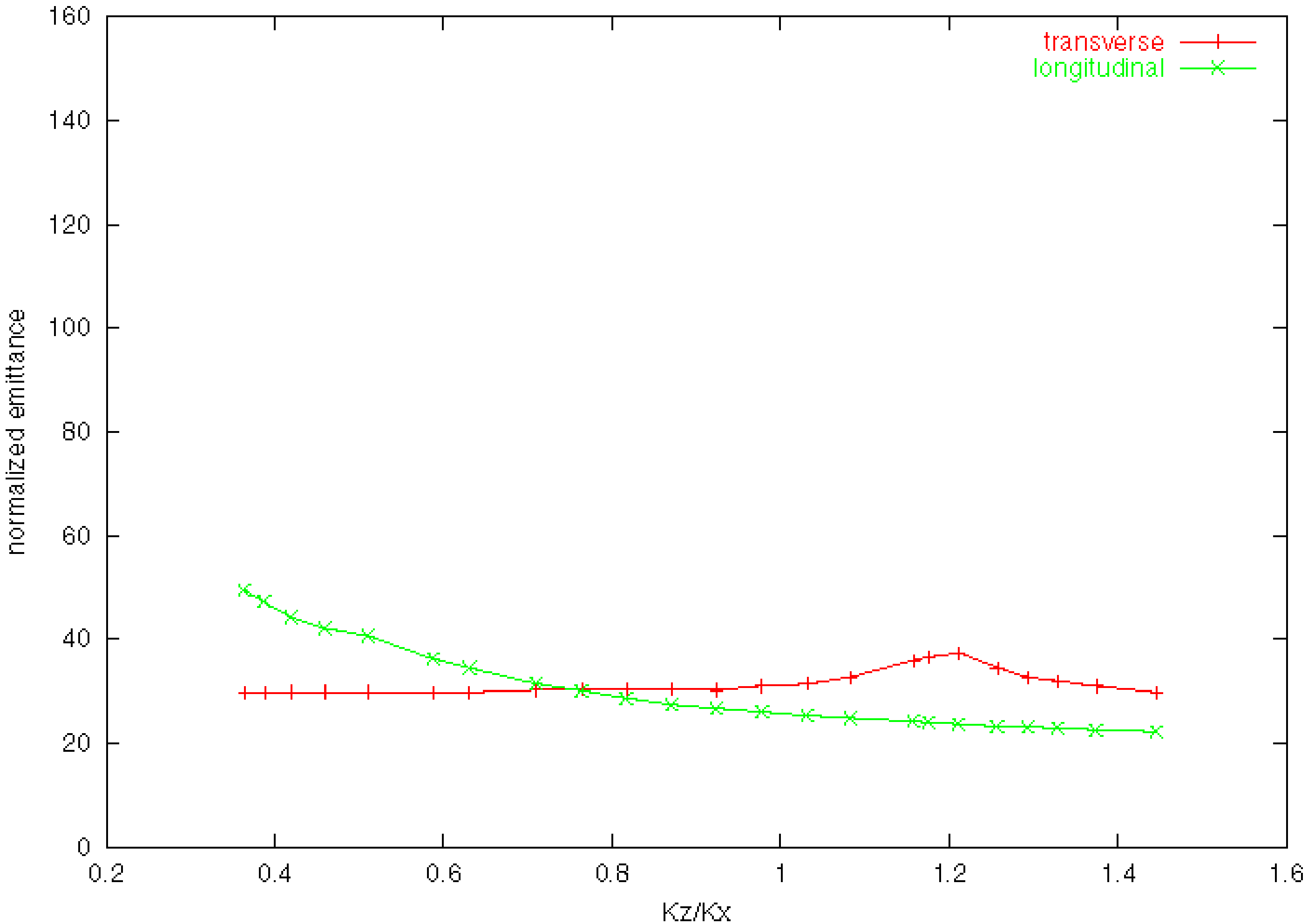
Final Halo Emittance (99.99% Emittance) vs. Tune Ratio in a Mismatched Anisotropic Beam

(Kx/Kx0 = 0.6, Ez/Ex = 2, Gaussian Distribution.)



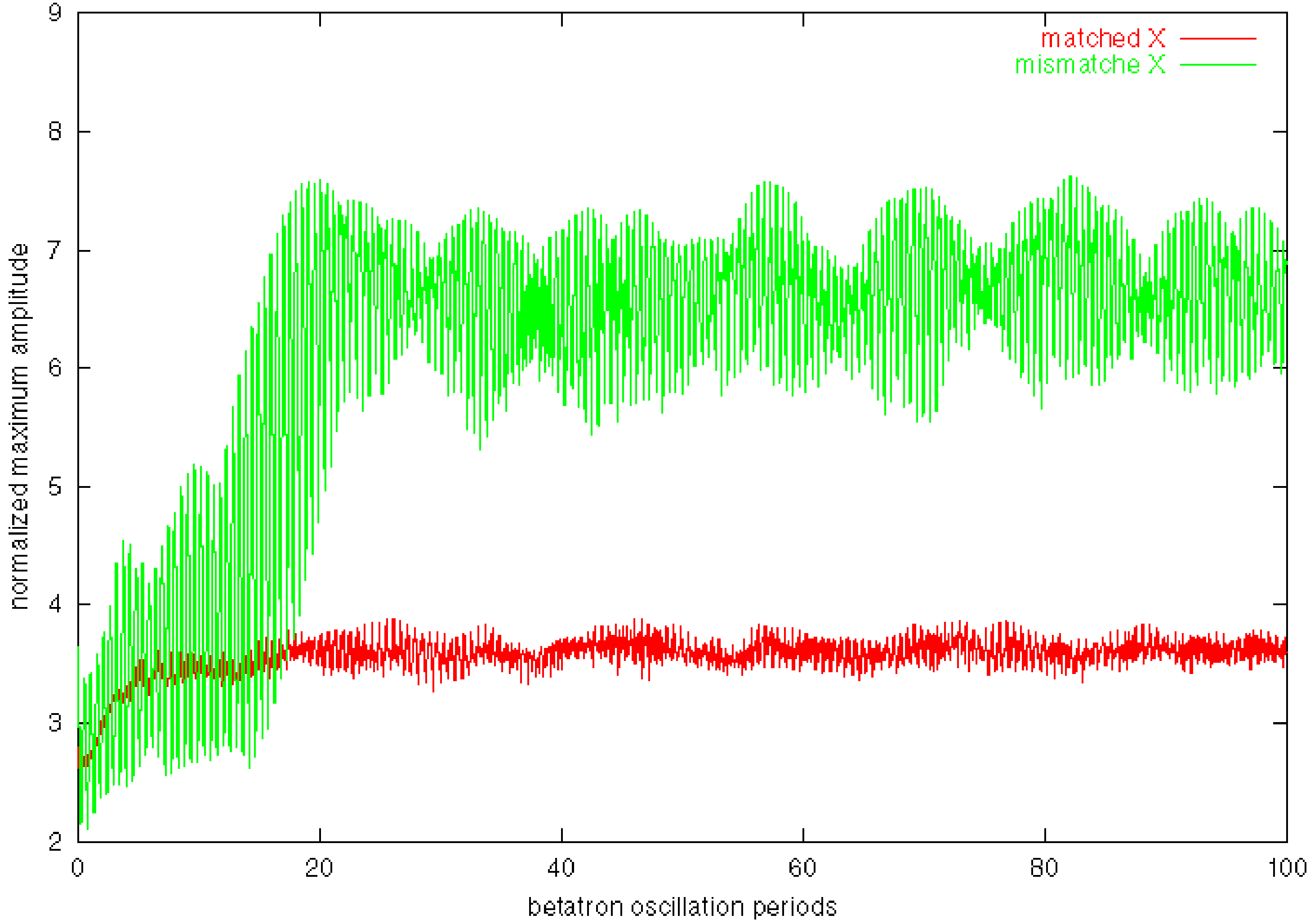
Final Halo Emittance Growth vs. Tune Ratio in a Matched Anisotropic Beam

(Kx/Kx0 = 0.6, Ez/Ex = 2, Gaussian Distribution)



Transverse Maximum Amplitude Evolution in a Matched and Mismatched Anisotropic Beam

(Kz0/Kx0 = 1.0, Kx/Kx0=0.6, Kz/Kx = 1.21, Ez/Ex = 2, Waterbag Distribution)

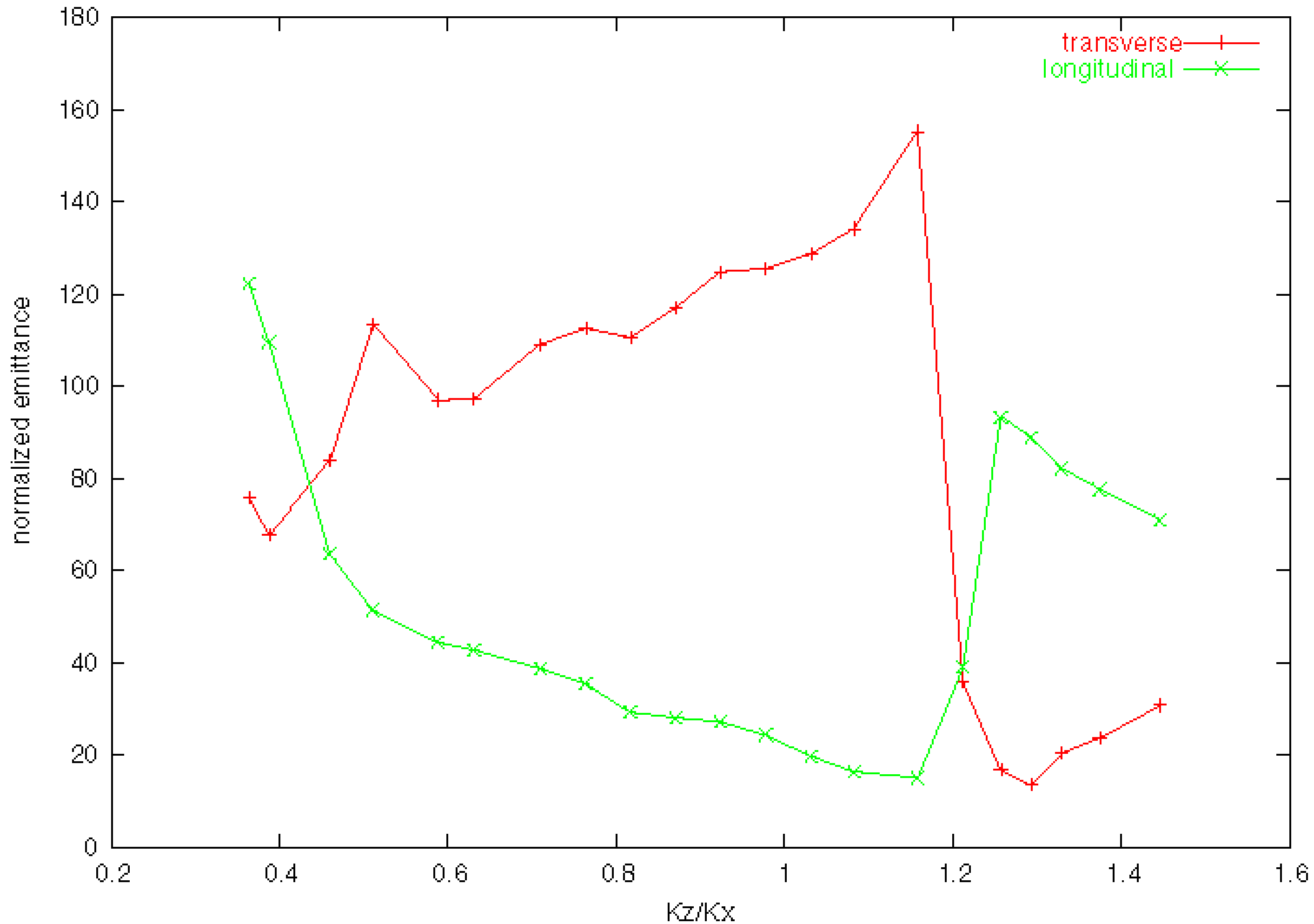


Conclusions

- Emittance growth in a mismatched anisotropic beam results from the superposition of the equipartitioning and mismatch induced halo.
- Mismatched anisotropic beam does not necessarily approach to final equipartition even within the major 4^{th} order coupling resonance.
- Averaged emittance growth per degree of freedom follows the upper bound of the free energy model.
- Halo emittance growth is dominated by the mismatch induced halo.

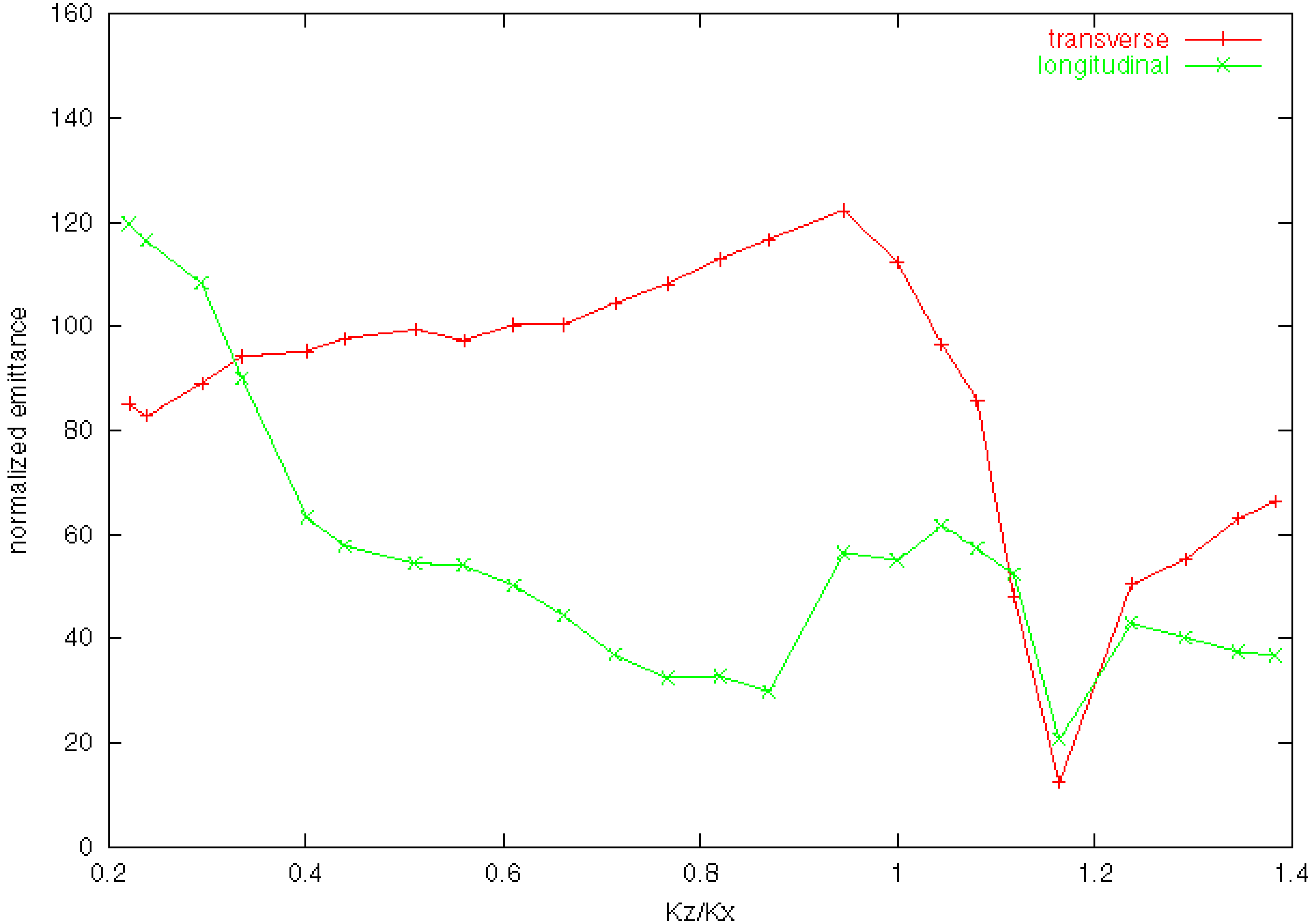
Final 99.99% Emittance Growth vs. Tune Ratio in a Mismatched Anisotropic Beam

(Kx/Kx0 = 0.6, Ez/Ex = 2, Waterbag Distribution.)



Final 99.99% Emittance Growth vs. Tune Ratio in a Mismatched Anisotropic Beam

(Kx/Kx0 = 0.6, Ez/Ex = 1, Gaussian Distribution.)



RMS Emittance Evolution in a Matched and Mismatched Anisotropic Beam

(Kz0/Kx0 = 0.52, Kx/Kx0=0.6, Kz/Kx = 0.22, Ez/Ex = 1, Gaussian Distribution)